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# INFORMATION SYSTEMS INTEGRATION MECHANISMS WITHIN SUPPLY CHAIN AGILITY IN THE CHINESE AUTOMOTIVE INDUSTRY

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## Abstract

*Information systems are a critical factor in achieving supply chain agility in fluctuant markets. However, there has been limited research on identifying specific mechanisms on how information systems may affect supply chain agility. We address this gap by illustrating that IS complements supply chain agility on various operational dimensions, such as flexibility, responsiveness and dependability. We develop a conceptual model to explicate the significance of IS on several critical operational dimensions drawing examples from the context of the Chinese automotive supply chains.*

*Keywords: Information system integrations, supply chain agility, flexibility, responsiveness*

# 1 INTRODUCTION

Information systems are recognised as a competitive tool in achieving supply chain agility (Power *et al.*, 2001; Yusuf *et al.*, 2004) but there is little research or understanding of the mechanisms by which IS integration may affect supply chain agility. This paper considers possible mechanisms within the context of the emerging Chinese automotive industry

A conceptual model is developed to explore IS integration and its impact in the context of supply chain agility.

As this is an exploratory study, a case study based methodology has been deployed. Customers, first and second tier suppliers within one supply networks were interviewed.

The study recognizes the constraints of integrating IS in the context of achieving agile capabilities, and enhances the existing evidence on the impact of IS integration.

## 2 LITERATURE REVIEW

The concept of supply chain management is introduced and the reason for agility becoming an important issue within the field. Supply chain agility determinants are identified including the role of information systems integration in supporting operational performance. This leads to the development of four propositions for IS integration and the development of a research framework showing the relationships between IS integration, supply chain agility and operational performance.

### 2.1 Supply chain management

In today's markets, firms face stiff competition due to time-based competition and fast technology development. Sustainable competitiveness is focussed on supply chain management (SCM) (Swafford *et al.*, 2007). SCM usually consists of individual functional entities with commitments to provide related resources and information to achieve the objectives of efficient management of suppliers as well as the flow of parts (Lau and Lee, 2000).

SCM has evolved from traditional command and control, vertical hierarchy based organization to one structured around process units (van Hoek *et al.*, 2001). Traditional vertical integration is replaced by horizontal integration, involving outsourcing and inter-firm integration. Meanwhile, organizations are moving to mass customization which combines standardization and customization within one supply chain, as well as minimizing waste through overall business processes. Therefore, agility is becoming important as it is all about 'customer responsiveness and mastering market turbulences' (van Hoek *et al.*, 2001).

### 2.2 Supply Chain Agility

Supply chain agility can be seen as a measure of success of the relationships within a supply chain in the process of manufacturing, design, delivery and customer service (Yusuf *et al.* 2004), particularly responsiveness (Christopher and Towill 2000). This leads to the adoption of Christopher's (2000) definition of supply chain agility '*as a business-wide capability that embraces organizational structures, information systems, logistics processes and in particular, mindset*'.

The literature suggests that there are four determinants of success for supply chain agility. These are customer sensitivity, process integration, network integration and virtual integration:

- Customer sensitivity focuses on developing co-operative relationships with customers.
- Process integration focuses on core competences to change business processes.
- Co-ordination with partners is the key issue in network integration.

- Finally, virtual integration is about leveraging information across the supply chain (Christopher, 2000; Goldman et al, 1995; van Hoek, 2001).

These determinants are supported through organizational and supply chain design, information sharing among functional units (Crocitto and Youseff, 2003), internet-based collaboration and networking with partners rather than marketing alliances (Yusuf *et al.*, 2004) etc. Among these factors, IS integration has been identified as a key enabler to supply chain agility (Breu *et al.*, 2001; White *et al.*, 2005).

### 2.3 IS Integration

A key characteristic of supply chain agility is the instant availability of information to manage an 'on demand' business operation. IS integration provides the basis for information sharing and exchange and organizations (Yusuf *et al.*, 2004; Auramo *et al.*, 2005). There is some evidence that the lack of information sharing and sparse information prohibit supply chain coordination and lead to greater operational inefficiencies (Patnayakuni *et al.*, 2006).

An integrated information system requires the integration of communication, data and application (Muller *et al.*, 2007; Ross, 2003) to enable consistent and real-time connectivity among function units across supply chains (Rai *et al.*, 2006). However, IS cannot, per se, create any sustained performance or values (Powell and Dent-Micallef, 1997). Therefore, it is important for companies to integrate resources and embed them in their social and cultural context (Barua *et al.*, 2004) to develop operations and workflow coordination (Rai *et al.*, 2006).

Therefore, we shall adopt the definition of IS integration developed by Rai *et al* (2006). This has two aspects: data consistency and cross-functional SCM application system integration. Data consistency is 'the degree to which common data definition and consistency in stored data have been established across a focal firm's supply chain' (Rai *et al.*, 2006). Cross-functional SCM application system integration is 'the degree of real time communication of a focal firm's function-specific SCM applications with each other' (Rai *et al.*, 2006), such as planning applications, transaction applications and the connectivity with ERP etc. Planning applications support planning for procurement, production, and logistics. Transaction applications realize the execution of order management, production management and distribution (Kalakota and Robinson, 1999).

### 2.4 IS Impacts on Supply Chain Agility

The literature review indicates that IS integration can significantly enhance supply chain agility thus improving operational performance the literature review lead to four propositions this research investigates.

#### **P1: IS has a positive impact on responsiveness to changes in production and services, and to market demands on new products.**

Customer sensitivity emphasizes customers and markets, including customer-focused logistics and rapid response. Supply chains are becoming demand-driven rather than forecast-driven in order to effectively respond in real-time demand. Firms rely heavily on forecasting techniques to predict manufacturing and inventory based on historical data due to lack of direct feedback from market. But IS integration within and among organizations enables them to capture data on demand, leading to customer-focused supply chains (Christopher, 2000).

Firms are more likely to gain competitive advantage through fast delivery and product variety rather than price. Therefore, the effectiveness of supply chains can be measured by its responsiveness (Lee and Billington, 1992). Through sharing and transferring real time information among suppliers and customers, IS encourages a fast response to market requirements.

**P2: IS increases the degree of dependability among partners in the supply chain.**

There is a growing recognition that companies need strategic partnerships with shared targets to compete in competitive markets. Therefore, in order to sustain competitive advantage, it is critical to leverage the strengths and competencies of partners to realize fast responsiveness to market requirements (Christopher, 2000). For example, in the automotive industry, first tier suppliers are involved in the design of car components and at the same time, automotive companies help their manufacturing process and technology improvement (Martinez and Perez, 2005). Thus dependability among partners, such as the performance of suppliers in terms of speed and reliability of delivery is key (Narasimhan and Jayaram, 1998).

**P3: IS improves product and volume flexibility along the supply chain.**

Process integration is related to uncertainty across the supply chain, placing emphasis on self-management teams instead of standardization so that core modules of products can be delegated within networks of agile competitors. Therefore, alliances among various suppliers, manufacturers and customers will be inevitable (Christopher and Towill, 2000), and it enables collaborative working methods such as joint product design. For example, Taiwan Semiconductor Manufacturing Company gives suppliers proprietary tools and data of the product requirements so that they can execute changes accurately. Therefore, while focusing on their own competencies, companies are much more likely to increase product variety and improve the ability to handle orders with special customer requirements. Meanwhile, with the availability of real time demand data, it improves company volume flexibility - that is, increasing or reducing production based on demand. Flexibility is another important operational dimension which can improve the company's competitiveness (Martinez and Perez, 2005), and in the context of supply chain, it is a significant measure for supply chain performance (Vickery *et al.*, 1999).

**P4: IS positively impacts information acquisition and information dissemination of organizational learning.**

Virtual integration emphasizes leveraging people and information along the supply chain. Supply chains can be structured around the flow of information to ensure that members within organizations along the supply chain have access to relevant information (Tippins and Sohi, 2003). IS integration enables more effective information gathering and dissemination between customers and suppliers to make consensus focussed development more efficient, thus contributing to organizational learning (Tippins and Sohi, 2003). Given the complex and often dynamic nature of supply chain management, organisational learning has been presented as one key dimension of competitive supply chains (Hult *et al.*, 2000).

From these propositions a framework demonstrating the operations impact of IS integration on agile capabilities of the supply chain is proposed (see Figure 1).

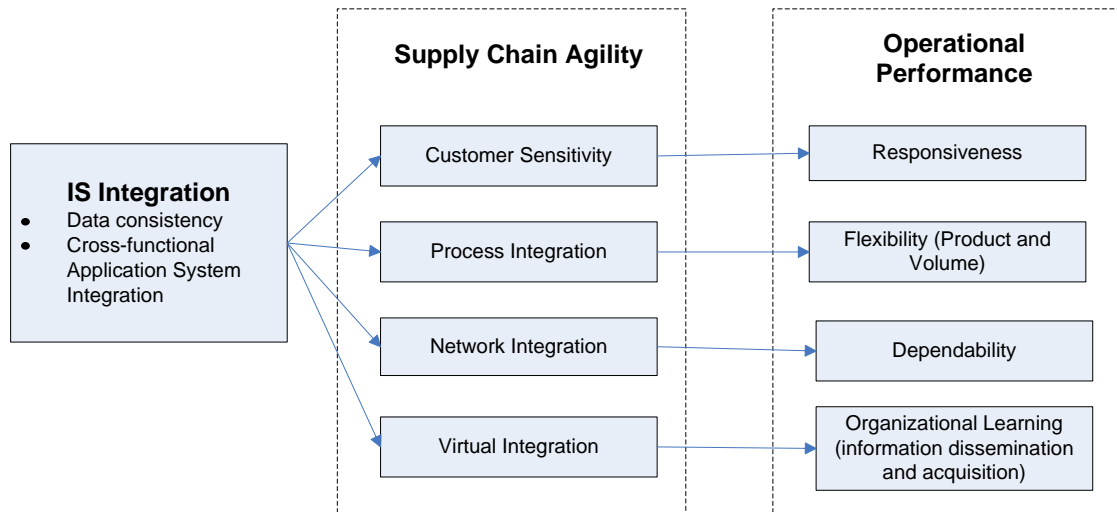


Figure 1 Research framework

### 3 BACKGROUND TO THE RESEARCH: THE CHINESE AUTOMOTIVE INDUSTRY

The Chinese automotive industry is suitable for this study for a number of reasons. To begin, the Chinese automotive industry is one of the leading markets in the world with sales and production (Gao, 2005). Significant parts of the industry are subject to government intervention. For example, the location of certain equipment and parts manufacturers is determined by the government in order to further regional policy. Many western automotive manufacturers are working in collaborative partnerships with Chinese firms to develop the market.

With the increasing emphasis of sourcing all production within China, the issue of SCM is becoming of importance in the business (Thru, 2006). Facing intense competitions for market share and achieving high requirements, agile capability is becoming vital to supply chain operation in the Chinese automotive industry (Chen 2004). As supply chain maturity and complexity increases automotive firms seek to improve business processes and technology by pushing other members of their supply chains to adopt IT (Fulcher (2004). IS applications have reshaped the automotive manufacturing sector towards the goal of building vehicles to customer orders (Howard, 2005).

### 4 RESEARCH METHODS

The research has been carried out through multiple case studies. Case studies are useful when exploring new areas of research (Eisenhardt, 1989), particularly in information systems because they cope with technical situation with many variables (Yin, 2003). Three case studies of supply chains are investigated. The supply chains are shown in Table 1 below.

Company	1 <sup>st</sup> Tier supplier	2 <sup>nd</sup> Tier Supplier	Description
A			A joint venture of auto-making with one European company.
	A1a		A joint venture with one American company for producing harness to company A and B, with 1,500 employees.
	A1b		A state-owned SME, manufacturing sampling parts for automotive.
		A2a	A joint venture of manufacturing connector for A1a, with 1,000 employees.
B			A joint venture of auto-making with one American company
C			A joint venture of auto-making with one Korea company
	C1		A joint venture of producing automotive seating systems for C
		C2	A company with 100% foreign investment, producing injection mouldings for C.

*Table1: Supply chain case firms*

Open-ended questions were developed to test the propositions and to explore the issues related to IS integration and supply chain agility. Forty semi-structured interviews were conducted to collect data from senior managers in the departments related to IS, procurement, manufacturing, and logistics within all the organizations. Interviewees included eight senior managers at IS departments, twenty nine senior managers at departments related to supply chain, two general managers and one CEO. Each of the interviews lasted between half an hour to one hour. The interviews were taped under interviewees' permission. Confidentiality of the participant firms was assured.

In order to minimize the bias of interpretation, a summary of the interview was written up and passed back to interviewees in order to justify and improve the accuracy of our understanding of each interviews. 45% feedback has been received. Each interview was coded using NVivo to identify the way of communication, the level of IS integration and the operational performance through integration processes, according to identified specific themes presented in the research model.

## 5 RESULTS AND DISCUSSION

IS integration issues between OEMs and their suppliers are analysed. These indicate that there is some support for the four propositions between OEMs and first tier suppliers, but less for second tier suppliers. The propositions are discussed and the research framework (Figure 1) is revised.

### 5.1 Information system integration across supply chains

OEMs in this research developed their IS through different periods, leading to more than 200 legacy systems. ERP are used by the OEMs to help integrate the processes but IS managers have some concern on compatibility.

First tier suppliers usually set up plants close to OEMs. Therefore, each plant only has one customer—the OEM that is close to the plant, so that they can have a greater responsiveness. In the plants, MRP systems are used. These systems are developed by their headquarters, where the IS department is located. Second tier suppliers also have MRP systems. The systems in OEMs usually are much more complex compared to their suppliers.

The use of IT for communication along the supply chain is limited (see Figure 2). IS is applied at more advanced level between OEMs and 1<sup>st</sup> tier suppliers where OEMs usually provide the technology. Portals are adopted to publish and exchange general information, such as long term planning from OEMs and order confirmation from suppliers. WebEDI is used to deliver daily schedules to 1<sup>st</sup> tier suppliers. JIT delivery for auto-parts is used by 1<sup>st</sup> tier suppliers to OEMs. E-mail is the main means of communication between 1<sup>st</sup> tier suppliers to 2<sup>nd</sup> tier suppliers.

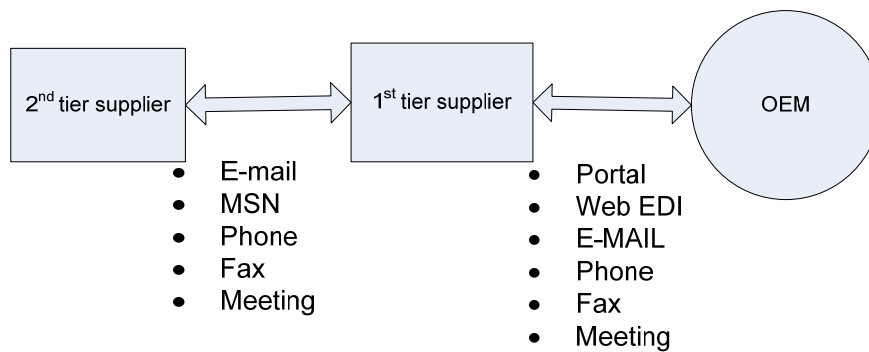


Figure 2 Communications from 2<sup>nd</sup> tier suppliers to OEMs

More OEMs are switching from importing components as local 1<sup>st</sup> tier suppliers component prices are low and their quality improves (Thru, 2006). This encourages the use of integrated IS between OEMs and 1<sup>st</sup> tier suppliers. The technology has been provided by OEMs. Where both 1<sup>st</sup> and 2<sup>nd</sup> tier suppliers are SMEs, IS integration is problematic. They prefer communicating through instant messenger, or telephone etc, as one senior manager said *'it is much easier and cost-effective to communicate in this way than using information systems.'* 1<sup>st</sup> tier suppliers may have portals provided by their headquarters or by application service providers to communicate with 2<sup>nd</sup> tier suppliers. No direct communication has been set up between 2<sup>nd</sup> tier suppliers and OEMs.

Specifically, common data definition and consistency has been set up 1) between OEMs and 1<sup>st</sup> tier suppliers, such as car model, and 2) between 1<sup>st</sup> tier suppliers and 2<sup>nd</sup> tier suppliers, such as auto parts. It has been regarded as the basis of integrating IS.

The study shows that the cross-functional application systems integration did not take place across a focal firm's supply chain, instead portals or webEDI are more commonly used to link partners across supply chains. As a senior OEM manager says, *'it works well in this way so far and at present, the business does not require the whole integration of systems'*.

## 5.2 Achieving agile capabilities of supply chains

Proposition 1 proposed that IS has a positive impact on responsiveness to changes in production and services, and to market demands on new products. The proposition was developed from the impact of IS integration in the context of achieving customer sensitivity. Many organizations have intention to implement build-to-order (BTO) to fast respond to customers. Interviews from suppliers indicate that suppliers still have to respond to volatile OEM schedules changed at the last minutes and with relatively little adherence to the original plans. However, *'compared to the time without integrated IS, the extremely volatile changes are becoming less and less'* (Senior manager from 1<sup>st</sup> tier supplier). This leads to problems for BTO *'If operations are executed only based on BTO, without order confirmation, the production line will cease. The worst scenario is to stop the production line, partially because of the cost issue.'*

The study indicates that firms have a better understanding of the market and customer requirements as a consequence of IS integration Integrated IS helps to gather and analyze available information on existing and potential customers to plan more effectively through synchronizing data across supply chains. The OEM's role is critical in supply chains because their forecast or manufacturing long/short time planning influences suppliers.

The second proposition proposed that IS increases the degree of dependability among partners in the supply chains. All interviewees agreed that IS integration does help to achieve a closer relationship between OEM and 1<sup>st</sup> tier suppliers by providing real-time manufacturing data or sharing production planning etc, so that a greater responsiveness from suppliers can be achieved.



Internet portals standardize communication between OEMs and 1<sup>st</sup> tier suppliers. IS integration simplifies design processes and specialized product development and core competencies within the firms.

The study shows that real time communication helps to increase the efficiency of sequenced in-line supply operations by providing up-to-date information. This helps suppliers anticipate changes in the production schedule preventing material short-falls and improving responsiveness. However, 1<sup>st</sup> tier suppliers expressed their concern with IS integration in terms of data visibility.

The study finds no direct link between OEMs and 2<sup>nd</sup> tier suppliers. The level of IS integration between 1<sup>st</sup> and 2<sup>nd</sup> tier suppliers is limited, with cost and responsiveness cited as the main reason. 2<sup>nd</sup> tier suppliers implement MRP or MRPII within the organizations, but some resist IS integration, because it will introduce an extra layer of complexity to the existing systems and requires training and investment. The proposition is supported by OEMs and 1<sup>st</sup> tier suppliers but it is not clear for the 2<sup>nd</sup> tier suppliers.

The third proposition proposes that IS improves product and volume flexibility along the supply chain. Interviews demonstrate that with IS integrated in business processes; it improves the traceability or ownership such as product in serial number, time of manufacturing, the employee number etc. With the capability of being traceable, the following result will be the quality improvement, as discussed from managers.

However, IS does not improve the product and volume flexibility when the changes have been made in short notice. The reason for prohibiting flexibility is IS computerized the business processes, and it is difficult to make changes with short notice. However, if the changes are made before the beginning of IS processing time, IS does help of being flexible, especially by integrating and synchronizing data across chains. It is noted that some managers agree with the propositions, but the majority question the propositions. Hence, the research takes the majority into consideration.

The fourth proposition suggests that IS positively impacts on information acquisition and information dissemination of organizational learning. The study shows that IS integration will not be implemented unless require by the business strategy. Matching IS to their competitive priorities involves identification of those priorities, such as cost, quality, dependability. With the business strategy, firms should seek best IS competencies to further develop business strategy. *'Now it is much easier for us to find the data I want across functional units without running around company to gather the data. It saves lots of time so that we can actually have more time to analyze data and make decision'* (senior manager from OEM).

Currently firms are operating in connected links but not viewing them as a holistic chain. Therefore, supply chain agility is limited. The relationship in the participating companies tend to be based on cost-reduction, even through they intend to build the relationship on value-adding.

However, with continuous effort on SCM and on implementing IS, partners are beginning to benefit from IS integration in terms of operational performance compared to the time without integrating IS. The overall operations can be more efficient, responsive, traceable, and dependable.

The findings from the study lead to the development of a revised research framework (see Figure 3) that indicates IS integration is influenced by cost, which acts as an inhibitor. Application integration is refined to include the use of portals and real time information transformation. Additional factors influence supply chain agility and operational performance. Customer sensitivity is more focussed on production capacity rather than overall sensitivity to the market. Hence, forecast accuracy rather than responsiveness is the operational performance outcome. Virtual integration is determined by business requirements, primarily within the OEMs. There is a clear recognition of the need to have better information that can be used to support production efficiencies, thus supporting the proposition that virtual integration leads to organizational learning. Process integration is influenced by organisational maturity. This leads to the introduction of a new aspect of operational performance, product quality control or ownership which leads to business process optimization. However, flexibility is still contentious. Network co-ordination is dependent on the development of relationships between

suppliers and OEMs. Responsiveness to changes in orders and products is important here. By recognizing core competences, dependability is appreciated. .

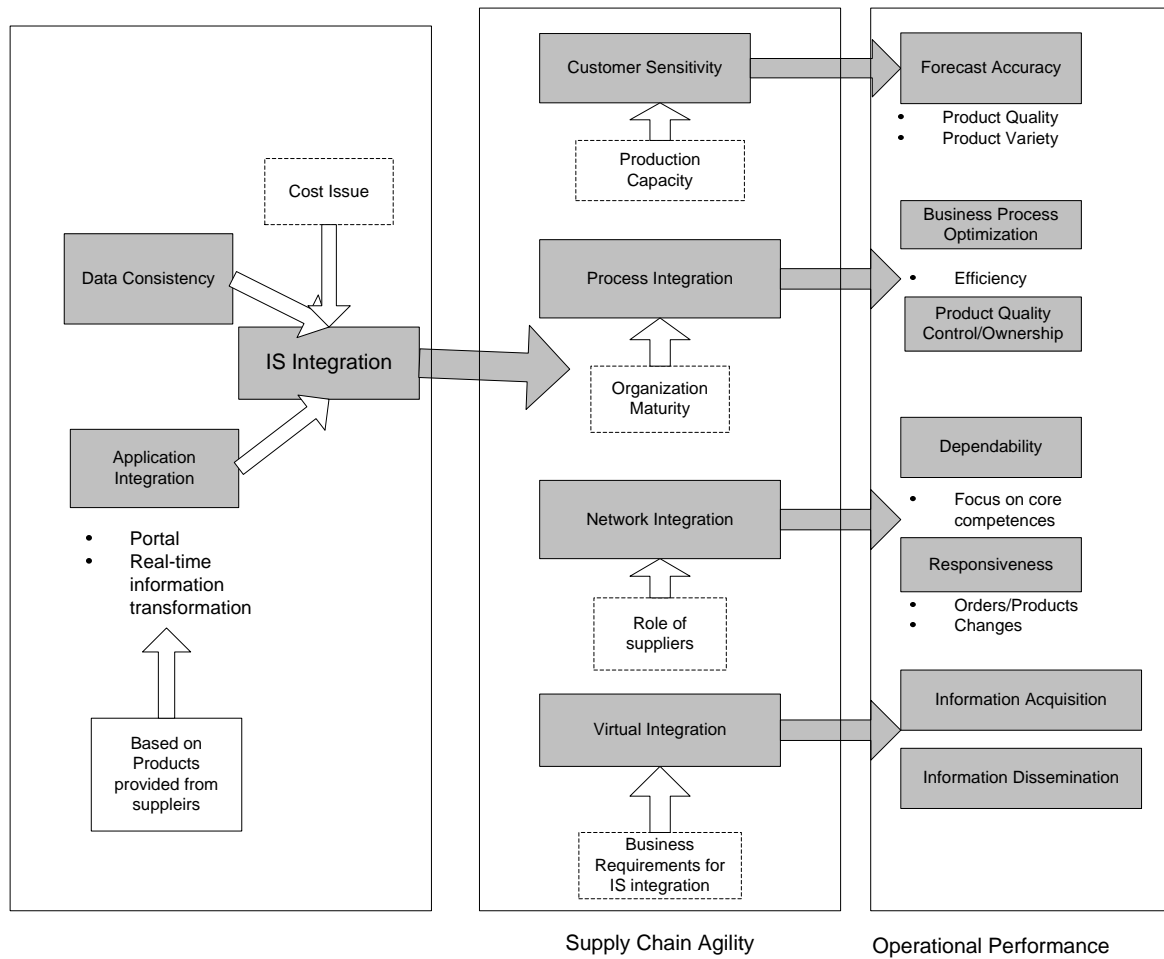


Figure 3: Revised Research Framework

## 6 CONCLUSIONS

In this paper, we investigated indirect links of IS integration and corporate value creation. In doing so, we focused on supply chain agility. Our research is motivated by the importance of IS on supply chain agility in complex manufacturing environments such as Chinese automotive industry. We developed a conceptual model to address the theoretical gap of IS, supply chain agility. The empirical research demonstrated the operational performances that IS integration impact on various integration processes. Although there is a great improvement of information visibility across supply chains, we can still see the pains of suppliers from interviews. Certain levels of data are treated as business secrets for example real time front-end data (demands from car dealers) can not be accessed by suppliers. Hence, transparency of information is still lacking, compounding further inherent upstream problems (Childerhouse *et al.*, 2003). Suppliers expressed that IS integration really helps to obtain data, but they hope, they can get the real time front-end data with further integration, including demands and sales so that they can have a better product plan and cooperation with regarding to product delivery, inventory management ect.

Furthermore, the empirical research enhances existing evidence on the impact of IS integration on supply chain agility. The study also recognized that the constraints of achieving operational performances from various integration processes through integrating IS, such as the consideration of

production capacity, Business requirements, cost issue etc. We also provides an in-depth understanding of Chinese automotive supply chains in the IS integration and the way of integration various processes and the way to maximize the benefits from IS integration in Chinese business.

Further investigation needs to validate the revised model, along with the emerging concepts pertaining to customer sensitivity, process integration, network integration and virtual integration in achieving agile capabilities of supply chains. As IS plays an increasingly important role in enabling the operations of business, developing such understanding at a theoretical level is critical. In addition, the research only focuses on automotive industry. Therefore, the model and propositions should also be tests on other industrial sectors.

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